REMARKS

Claims 6 to 11 are pending in the application.

Claims 1-5 have been canceled and the subject matter thereof has been incorporated into the new claims. Specifically, claim 6 is supported in the specification at least at page 14, lines 8-17 and in Examples 1 and 2, and claim 7 is supported in the specification at least at page 14, lines 17-20 and in Examples 1 and 2. Claim 8 is supported at least at page 14, line 21 to page 15, line 7; claim 9 at page 15, lines 7-10; claim 10 at page 13, lines 15-20, and claim 11 at page 13, lines 21-23. Claims 8-11 are also supported in Examples 3-5. No new matter has been added by these amendments.

In Paper No. 4, the Examiner has rejected claims 1 and 2 under 35 U.S.C. § 103(a) as being unpatentable over JP 11-214008 ("JP '008") in view of JP 11-3707 ("JP '707") and U.S. Patent No. 6,017,651 of Nimon et al. ("Nimon"). Claims 3 and 5 have also been rejected under 35 U.S.C. § 103(a) as being unpatentable over JP '008 in view of JP '707 and Nimon and further in view of U.S. Patents Nos. 6,372,387 of Kawakami et al. ("Kawakami") and 5,618,640 of Idota ("Idota"). Finally, the Examiner has rejected claims 3 and 4 under 35 U.S.C. § 103(a) as being unpatentable over JP '008 in view of JP '707 and Nimon and further in view of U.S. Patent No. 6,475,680 of Arai et al. ("Arai") and JP 10-162823 ("JP '823"). Applicants respectfully traverse these rejections as follows. Claims 1-5 have been canceled, rendering these rejections moot. However, Applicants respectfully submit that the rejections are also not relevant to new claims 6-11 as follows, and respectfully request reconsideration and withdrawal of the rejections.

Rejection Under § 103(a) Based on JP '008 in view of JP '707 and Nimon

The Examiner argues that JP '008 discloses a lithium battery comprising positive and negative electrodes, in which the positive electrode comprises a mixture of elemental sulfur powder, a metal complex of an organic sulfur compound having a thiol or thiolate group, and a conductive polymer. The Examiner acknowledges that JP '008 does not teach that the positive electrode comprises a lithium-sulfur compound represented by the formula $(Li_xS)_n$ or that the negative electrode contains a composite nitride of the formula $Li_{3-x}M_xN$, as claimed. However, Nimon allegedly teaches lithium polymer batteries, including a sulfur electrode containing elemental sulfur, lithium sulfide, and/or a lithium polysulfide. The Examiner further contends that JP '707 discloses a secondary battery comprising a negative electrode which contains $Li_{3-x}M_xN$ ($0.1 \leq x \leq 0.8$, M = Ti, V, Cr, Mn, Fe, Co, Ni or Cu).

Based on these alleged teachings, the Examiner concludes that it would have been obvious to one having ordinary skill in the art at the time of the invention to use a nitride of the formula $Li_{3-x}M_xN$, as taught by JP '707, as the negative electrode active material of JP '008 since JP '707 teaches that "deterioration of battery characteristics at high temperature storage times can be retarded" by using this active material. The Examiner further concludes that since Nimon allegedly teaches that lithium sulfide and polysulfides are functionally equivalent to elemental sulfur, it would have been obvious to substitute a lithium sulfide of Nimon (such as Li_2S_8 ($(Li_{0.25}S)_8$) for the elemental sulfur of JP '008. Applicants respectfully traverse this rejection as follows.

The object of the present invention was to develop a lithium battery capable of exhibiting high energy density at low voltage. In order to accomplish this goal, it was necessary to solve problems traditionally occurring with lithium batteries, namely, that pre-processes of intercalation and de-intercalation of lithium to or from the electrodes reduce the capacity, difficulties with capacity balance matching between positive and negative electrodes, and solving risks resulting from high voltage. More specifically, in lithium batteries, lithium is transferred between the positive and negative electrodes during charging and discharging, and it is preferable that initially only one of the electrodes contains lithium so that charging and discharging are possible without the presence of excessive, wasteful lithium. As taught in the specification, for prior art batteries which contain a combination of a sulfur-containing composite electrode and a carbon material, since neither electrode contains lithium, a process of intercalating lithium into one of the electrodes is needed during manufacture. Conversely, in batteries having a negative electrode containing a lithium-containing composite nitride and a positive electrode of $LiCoO_2$, a process for deintercalating lithium from one of the electrodes is needed during manufacture. Further, in both types of prior art batteries, it may be necessary to reduce the content of one of the electrode materials in the battery if there is too large a difference between the capacity densities of the two electrodes, thus not maximizing the high capacity characteristics.

However, Applicants have developed a battery in which neither of these intercalation or deintercalation processes are necessary, a battery in which both the positive and negative electrodes exhibit high energy density so that the combination is well balanced and the resulting battery exhibits high energy density. More specifically, Applicants have developed a battery which utilizes a lithium-containing composite nitride as a negative electrode and a composite electrode composition as a positive electrode which contains sulfur or lithium-

containing sulfur and a metal complex of an organic sulfur compound (M-SS). Applicants have found that the combination of sulfur or lithium-containing sulfur and M-SS results in a battery having a larger capacity that one with a composite electrode which contains only an organic sulfur compound (SS) and polyaniline (PAn). Further, in one embodiment, a battery containing a combination of M-SS, SS, and PAn yields high utilization, high reversibility, and high electric potential. The M-SS as a component of the composite electrode functions as an active material, and also prevents the SS and/or SS/PAn complex from dissolving in the electrolyte and dissipating from the positive electrode. Accordingly, batteries containing M-SS exhibit longer charge/discharge cycle life and a flatter voltage than those containing only SS and PAn. Further, Applicants have found that the use of a lithium-containing sulfur compound prevents a decrease in capacity and degradation of the cycle characteristics due to sulfur-sulfur aggregation or isolation of sulfur, which may occur in electrodes containing only sulfur. Accordingly, the claimed batteries, which may be produced from electrodes without the need for lithium intercalation or deintercalation processes, exhibit high safety, good capacity balance, low voltage, and high density characteristic.

In a preferred embodiment, recited in claims 6 and 7, initially, the positive electrode contains sulfur and a metal complex of an organic sulfur compound (M-SS) but no lithium, whereas the negative electrode contains lithium in the form of a lithium-containing composite nitride. Because only one of the electrodes initially contains lithium, charging and discharging cycles are possible without the presence of excessive, wasteful lithium; no processes for intercalation or deintercalation of lithium are needed.

In a second preferred embodiment, recited in claims 8-11, the negative electrode contains a mixture of a material containing no lithium originally, such as an alloy or metal oxide, and a material containing lithium, such as a lithium-containing composite nitride. Using these components together optimizes the content of lithium in the negative electrode. As a result, lithium deintercalated from the lithium-containing composite nitride is not directly intercalated into the positive electrode, but is captured into the alloy or metal oxide in its vicinity, thus solving problems of adjusting lithium content e.g., those relating to capacity and voltage. The prior art does not teach or suggest the claimed batteries as follows.

The Examiner contends that JP '008 discloses a positive electrode containing a metal complex of an organic sulfur compound. However, while the machine translation of JP '008 uses the term "complex" in paragraph [0011], the correct translation of the Japanese term is "composite," as seen in the corresponding U.S. Patent No. 6,245,458 (col. 4, lines 1-8, copy

enclosed). JP '008 teaches that the metallic copper or silver may give a composite with PAn and an organic sulfide compound, which prevents the composite from dissolving into the electrode and dispersing from the cathode. This metal, a conductive supporting member for the electrode mixture or a metallic powder, is added to the electrode mixture, and the composite is produced electrochemically by charge and discharge reactions of the electrodes (paragraph [0011]). The resulting composite has a complex molecular structure.

This type of composite is not equivalent to the claimed metal complex, such as that produced in Example 1 of the present application by mixing solutions of a thiadiazole compound (DMcT) and copper (II) chloride dehydrate to form a complex, $Cu(C_2HN_2S_3)_2$, which has two DMcT molecules coordinated to the copper ion. The claimed metal complex is a simple metal complex produced chemically outside of the battery system.

Furthermore, there is a distinction between a "composite" and a "metal complex." According to the *Condensed Chemical Dictionary*, (10^{th} Edition, Gessner G. Hawley, Ed., Van Nostrand Reinhold Company, New York (1991), abstracts attached) a "composite" is "a mixture or mechanical combination on a macroscale of two or more materials that differ in chemical nature." In contrast, a metal complex, or coordination compound, is "a compound (a substance composed of atoms or ions of two or more elements in chemical combination, in which the constituents are united by bonds or valence forces) formed by the union of a metal ion with a nonmetallic ion or molecule called a ligand".

Therefore, the composite of JP '008 is a macroscale combination, whereas the components of the claimed metal complex or compound are in chemical combination, and JP '008 does not teach or suggest a metal complex, nor is the formation of a metal complex described in the Examples of JP '008 as in the Examples of the present application. Accordingly, since JP '008 does not teach or suggest the claimed metal complex, and since neither Nimon nor JP '707 cures these deficiencies, even the proposed combination of references would not teach or suggest all of the claimed elements, and no *prima facie* case of obviousness has been established by the Examiner. Reconsideration and withdrawal of the § 103(a) rejection are respectfully requested.

Rejection Under § 103(a) Based on JP '008 in view of JP '707, Nimon, Kawakami and Idota

The Examiner acknowledges that JP '008 does not expressly teach that the negative electrode further comprises a metal oxide such as SnO or SnO_2. However, Kawakami allegedly teaches a secondary battery comprising a negative electrode containing a tin oxide, a

lithium tin oxide, and/or a lithium transition metal nitride, among other materials. Therefore, the Examiner concludes that it would have been obvious to one having ordinary skill in the art at the time of the invention to add tin oxide or lithium tin oxide to the negative electrode of JP '008 in addition to the lithium transition metal nitride. Furthermore, since Idota allegedly teaches that exemplary tin oxide active materials are SnO, SnO_2, and Li_2SnO_3, the Examiner concludes that it would have been obvious to use these materials in the negative electrode of JP '008. Applicants respectfully traverse this rejection as follows.

As previously explained, none of JP '008, JP '707, and Nimon teaches or suggests the claimed metal complex, and Kawakami and Idota do not cure these deficiencies. Furthermore, as previously explained, the alloy or metal oxide is incorporated into the negative electrode with a lithium-containing material, a lithium-containing composite nitride, in order to optimize the content of lithium in the negative electrode. As a result, lithium deintercalated from the lithium-containing composite nitride is not directly intercalated into the positive electrode, but is captured into the alloy or metal oxide in its vicinity and thus solves typical problems of adjusting lithium content e.g., those relating to capacity and voltage. In contrast, Kawakami teaches that the negative electrode contains a tin oxide, transition metal oxide, transition metal nitride, lithium tin oxide, lithium transition metal oxide, lithium transition meal nitride, lithium transition metal sulfide, transition metal carbide, lithium transition metal carbide, metal lithium, and/or a metal which is electrochemically alloyed with lithium (claim 23). Kawakami does not teach that the negative electrode contains at least one material which comprises lithium and at least one material which does not contain lithium, or the advantages obtained by utilizing such a combination of materials. Accordingly, since even the proposed combination of references would not teach or suggest all of the claimed elements, no *prima facie* case of obviousness has been established based on these references, and reconsideration and withdrawal of the rejection are respectfully requested.

Rejection Under § 103(a) Based on JP '008 in view of JP '707, Nimon, Arai, and JP '823

The Examiner acknowledges that JP '008 does not expressly teach that the negative electrode further comprises a tin or silicon intermetallic compound. However, Arai allegedly teaches a secondary battery comprising a negative electrode containing a nitride or an "intermetallic particle compound such as aluminum, tin, and the like," among other materials. Therefore, the Examiner concludes that it would have been obvious to one having ordinary skill in the art at the time of the invention to add tin or a silicon intermetallic material to the negative

electrode of JP '008 in addition to the lithium transition metal nitride. Further, the Examiner contends that JP '823 teaches exemplary tin and silicon intermetallic active materials, such as Si-Ni, Si-Fe, Sn-Fe, and Sn-Ni, and that it would have been obvious to use these materials in the negative electrode of JP '008. Applicants respectfully traverse this rejection as follows.

As previously explained, none of JP '008, JP '707, and Nimon teaches or suggests the claimed metal complex, and Arai and JP '823 do not cure these deficiencies. Accordingly, since even the proposed combination of references would not teach or suggest all of the claimed elements, no *prima facie* case of obviousness has been established based on these references, and reconsideration and withdrawal of the rejection are respectfully requested.

Even if any of the proposed combinations of cited references had been shown to teach or suggest all of the claimed elements, Applicants submit that no *prima facie* case of obviousness has been established, since there would be no reasonable expectation of success in the proposed combinations. Namely, in the field of batteries, it is difficult to predict whether or not the combination of a particular positive/negative electrode used in a specific system with another negative/positive electrode would yield a useful battery. For example, based on the unpredictable nature of the field, even one skilled in the art could not predict that the combination of the positive electrode of JP '707, the lithium sulfide material of Nimon, and the remaining components of JP '008 would yield a battery which exhibited favorable properties, particularly since none of these references teaches or suggests the benefits of utilizing a positive and a negative electrode, only one of which contains lithium, or a negative electrode which comprises one lithium-containing material and one material which does not contain lithium. However, Applicants have found through experimentation that typical problems related to capacity and voltage are solved for such batteries by utilizing these materials and by combination with a sulfur based organic compound positive electrode containing lithium sulfide, thereby providing lithium batteries having good cycle capacity and high energy density.

In view of the preceding Amendments and Remarks, it is respectfully submitted that the pending claims are patentably distinct from the prior art of record and in condition for allowance. A Notice of Allowance is respectfully requested.

Respectfully submitted,

YASUSHI NAKAGIRI *et al.*

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By: Sandra M. Katz

SANDRA M. KATZ
Registration No. 51,864
AKIN, GUMP, STRAUSS, HAUER & FELD, L.L.P.
One Commerce Square
2005 Market Street - Suite 2200
Philadelphia, PA 19103-7086
Telephone: (215) 965-1200
Direct Dial: (215) 965-1344
Facsimile: (215) 965-1210
E-Mail: skatz@akingump.com

WWS/SMK:smk

Enclosures: U.S. Patent No. 6,245,458
Abstracts from *Condensed Chemical Dictionary* (10th Edition, Gessner G. Hawley, Ed., Van Nostrand Reinhold Company, New York (1991)